Naval Postgraduate School
Center for INFOSEC Studies and Research

Data Integrity Limitations in Highly Secure Systems

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Outline

- Background
  - Integrity
  - High Assurance Systems
- Hybrid Security Architectures
- Integrity and HSAs
- Conclusion

Integrity

- *Dual* of Confidentiality
  - Labels indicate potential loss from
    - unauthorized modification
    - vs. unauthorized disclosure
- Translation from Confidentiality
  - inverted/convoluted
  - difficult concepts [Gasser]
- Analysis can be overlooked

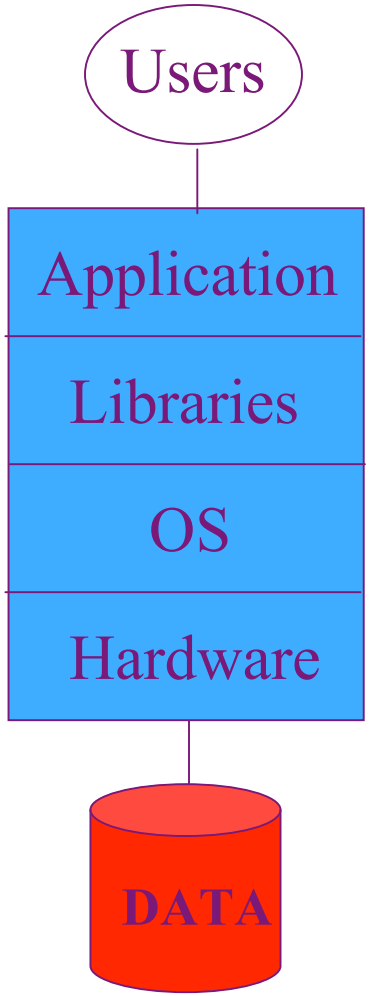
Integrity (2)

- **Inherent** Integrity and Confidentiality
  - explicit labels
  - or implicitly understood
- Unclear distinctions/assumptions
  - High confidentiality implies high integrity?
- Integrity of *Code*
  - fidelity to original - e.g., distributed version
  - fidelity to described intent
    - correct functionality
  - no additional functionality
    - trap doors, Trojan horses

High Assurance Systems

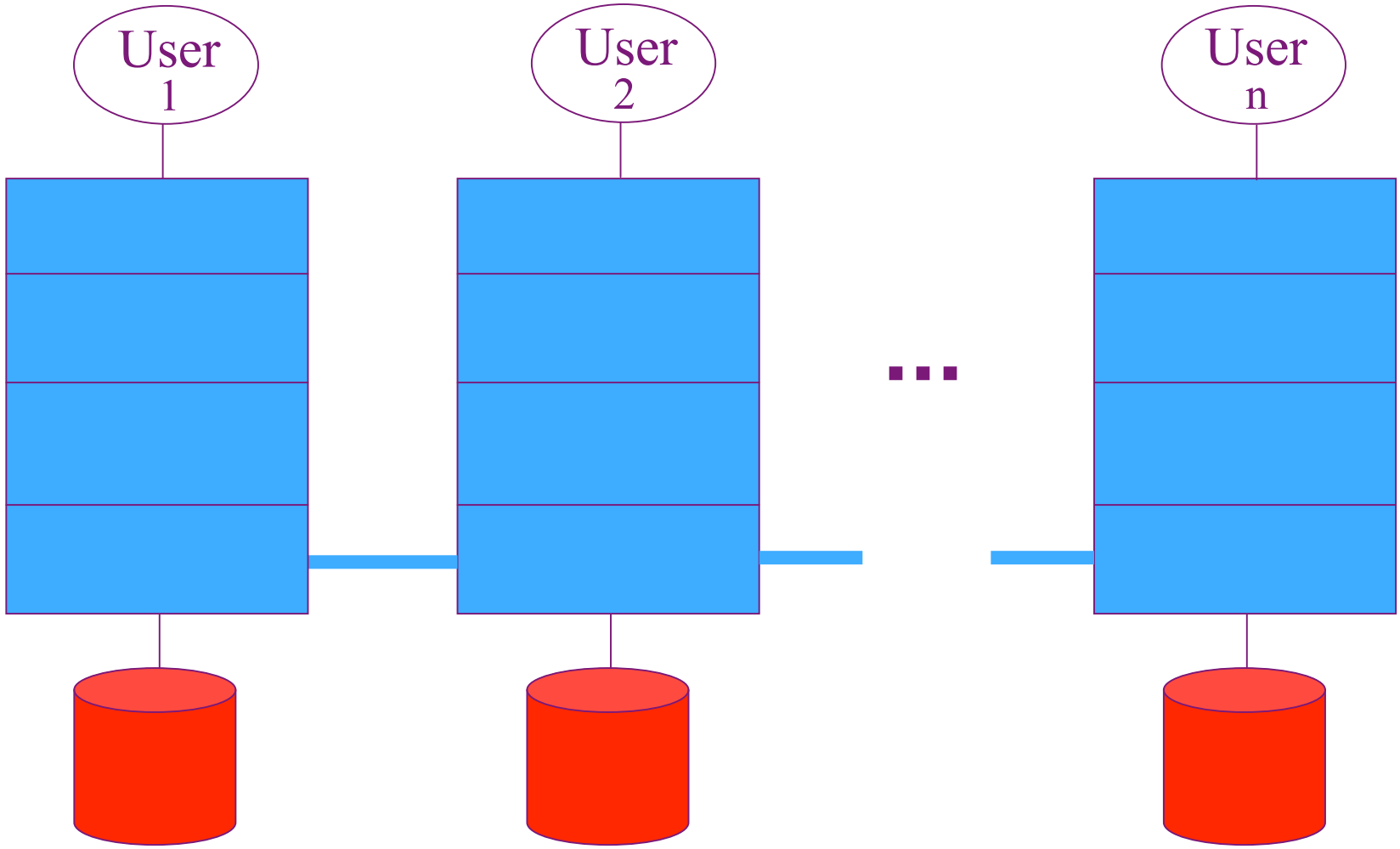
- Enforce confidentiality and integrity
  - to defined degree of assurance
- Various architectural approaches...

In the Beginning...



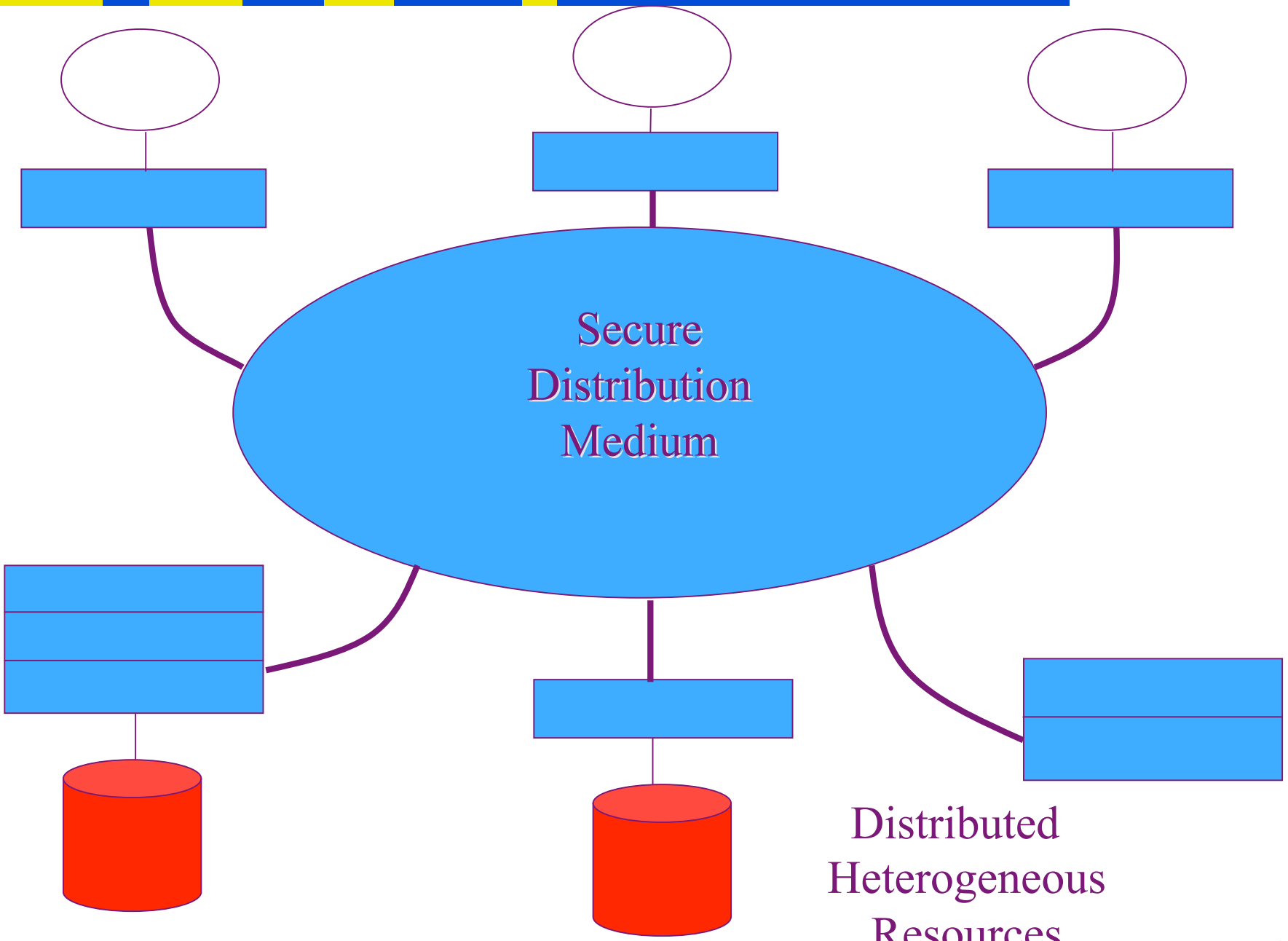
"Secure"

Distributed



Need to Generalize Remote Access

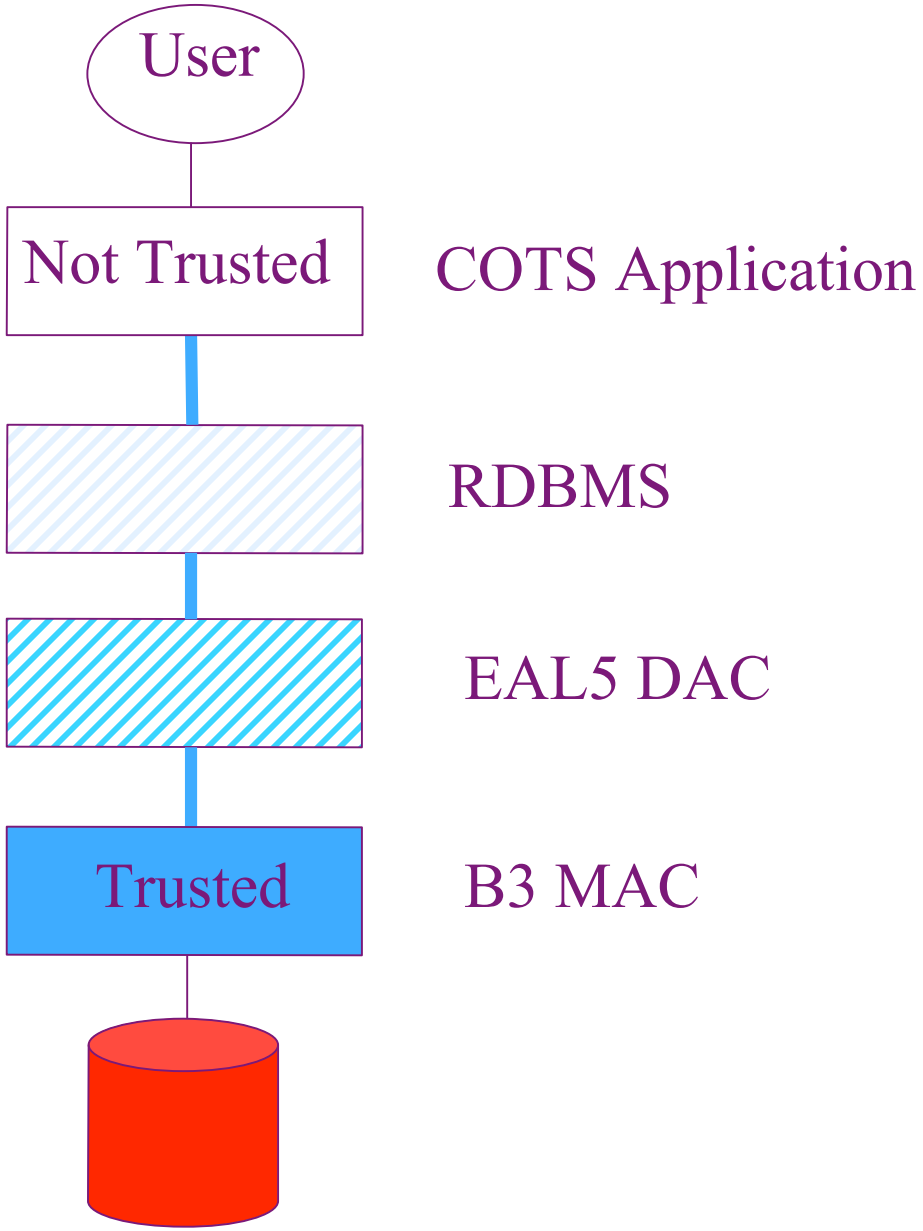
- remote programs
- remote data
- remote processors, devices


Secure
Distribution
Medium
Distributed
Heterogeneous
Resources

High Assurance Systems

- Expensive
- Incompatible, “stovepipes”
- Responses
  - COTS in Government RFPs
  - Balanced Assurance (at vendor initiative?)
  - TCB subsets

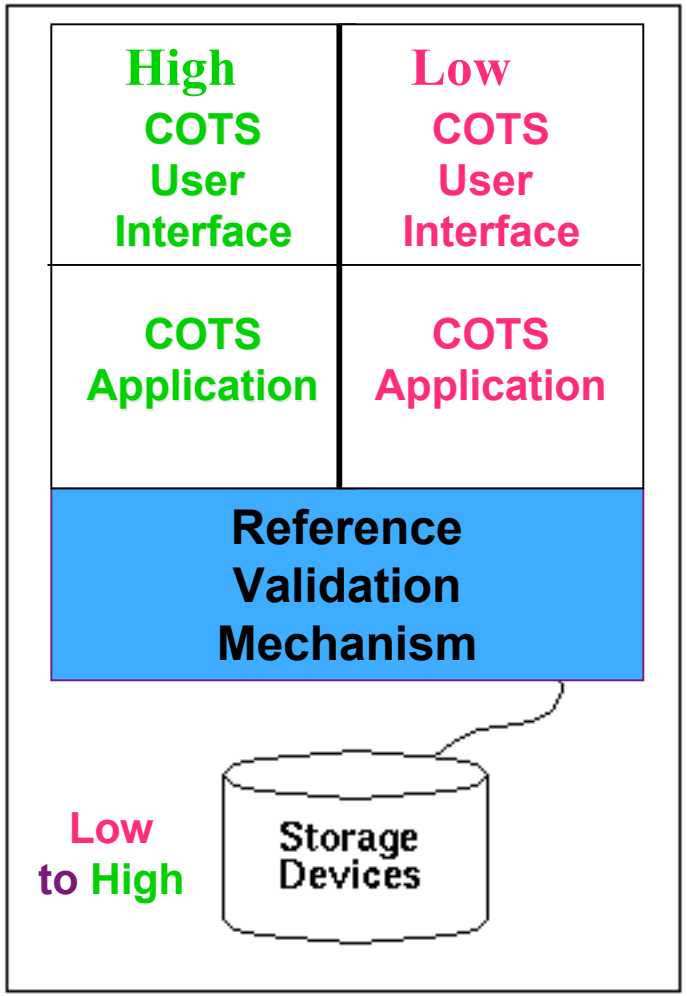
Balanced Assurance



Hybrid Security Architecture

- Balanced Assurance + COTS + MLS
- Configuration Components
  - Untrusted COTS terminals/workstations
  - Untrusted COTS applications
  - Storage devices
    - Multilevel data
  - Multilevel TCB mechanisms (RVM)
  - TCB extensions
  - Network Connections
    - single and multilevel

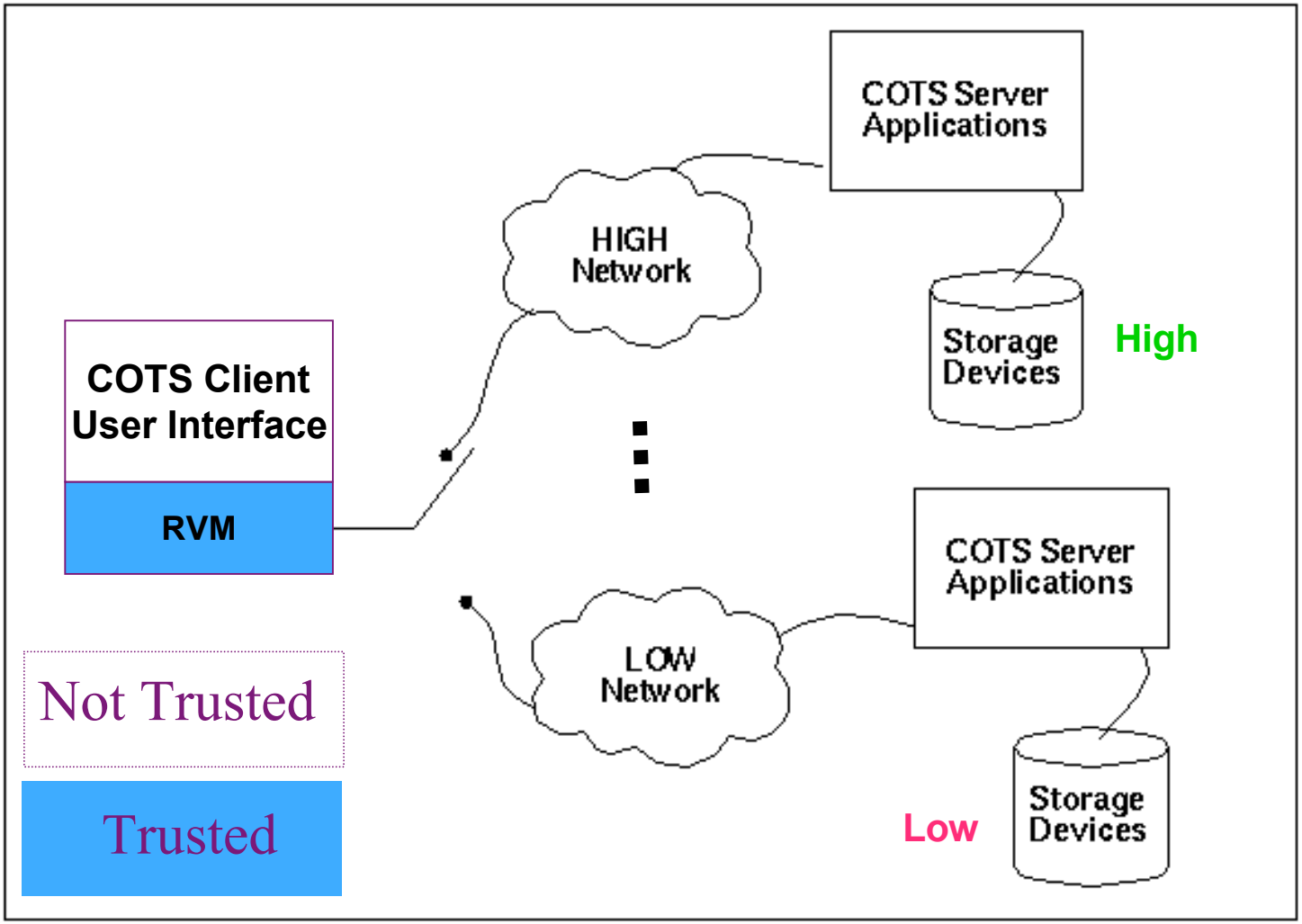
Monolithic



Not Trusted

Trusted

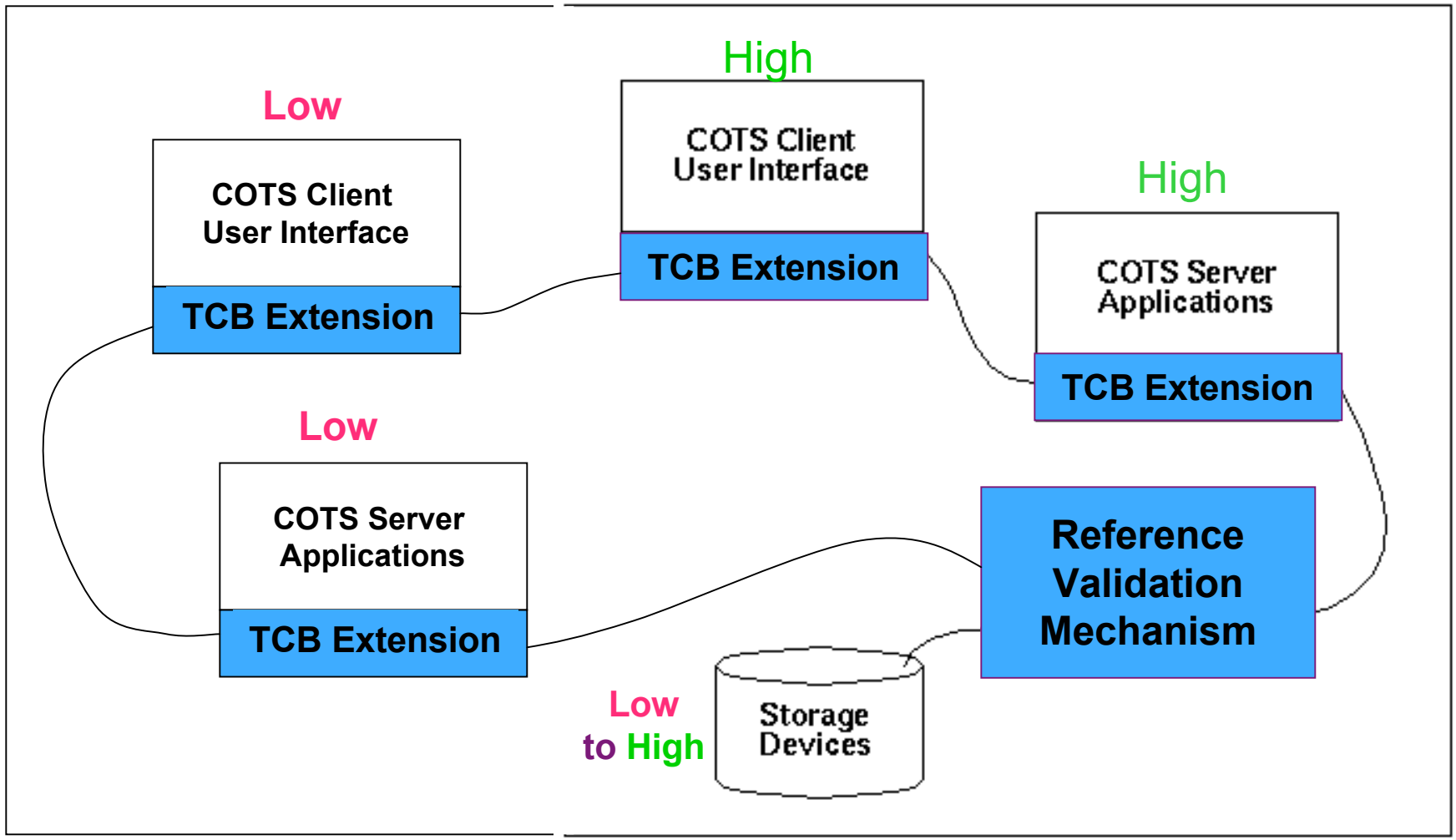
Switch-Based



Distributed

Trusted

Not Trusted



MLS Access Enforcement

- Reference Validation Mechanism
  - mediates access to objects
  - controls object creation, storage, access, I/O
  - prevents data *leakage* across MAC partitions
    - confidentiality write-down or read-up
    - integrity read-down or write-up (if enforced)
- Other modules constrained by RVM
  - leakage

System Confidentiality *Capacity*

- System trusted for confidentiality
  - to confidentiality capacity of reference validation module
    - capacity is relative to RVM assurance
    - Yellow Book
      - Maps assurance levels to confidentiality ranges
    - Policy enforced regardless of untrusted components

Data Integrity

- Integrity Semantics
  - dual of confidentiality
    - "prevents data contamination from untrusted software"
  - was the modification correct?
    - Within the partition
    - Code trusted to handle data correctly
      - to its level of assurance
    - No Yellow Book for integrity
    - Look to code integrity label

Code Module Integrity Label

- What the system designer needs it to be
  - Coherent network architecture
    - least privilege
  - Limit: pedigree of code

Trust in Commercial Applications

- Evaluation below B2/EAL5
  - little config. mgt. or code review required
    - no examination for Trojan horses/trap doors
    - no code correspondence
  - no trusted distribution
  - potential for unknown functionality
    - e.g., “Easter eggs” common in commercial software
    - testing doesn’t address unknowns
- Integrity is “low assurance” or “untrusted”
  - integrity label

System Integrity Capacity

- Some Code Modules can modify user data
  - set of Data Modifying Modules = *DMM*
- System integrity capacity:
  - integrity of **least-trusted** *Module*
    - I_capacity = $GLB_{(m \in DMM)}$ (integrity(m))
  - (system confidentiality capacity is:
    - capacity of reference validation module)

Integrity Capacity: two cases

- Integrity not supported
  - system can take in data higher in integrity than system
  - data output is lowered to integrity GLB of *DMM*
    - de facto label
- Integrity Supported by RVM
  - system regulates its own integrity capacity
    - ∀ m ∈ DMM, o: object (
      - » write (m,o) ⇒ dominates(integrity(m), integrity(o))
    - cannot take in data higher than integrity GLB of DMM
    - assumes modules/subjects are labeled correctly
    - problem not addressed by ring mechanisms

HSA and Integrity

- HSA applications and user interfaces
  - COTS
  - below B2/EAL5 (integrity *untrusted* or *low assurance*)
  - generally designed to modify data
- HSA systems have untrusted or low assurance integrity capacity
- Hybrid Security Architecture systems not suitable for environments with *trusted/critical* data integrity requirements

Summary

- Correct integrity labeling of code is critical
- *Code-module integrity* limits *system integrity capacity*
  - Not new information
  - Not always remembered
  - Not always communicated to sponsors and customers
- HSA systems not suitable in environments w/ *critical or trusted* data

Questions?

- Irvine, levin @cs.nps.navy.mil
- http://cisr.nps.navy.mil

Integrity Labels

- Subject consists of a set of code modules
- ∀ m: module, s: subject o: object(
  write(s,o) & m ∈ s
  ⇒ integrity (m) ≥ integrity(s) ≥ integrity(o))

≥ - enforced by design/configuration

≥ - enforced by RVM

Need both for coherent integrity enforcement

- (Dominates “≥”)

Vertically Distributed